Grounding

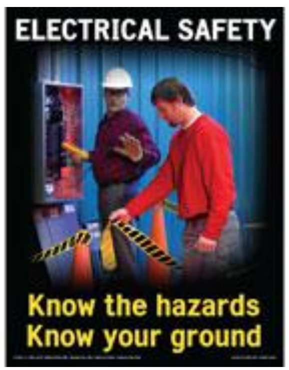
Grounding Systems in the Ham Shack

Organizing an Effective Grounding System in the Ham Shack

There's More Than One Way To Get a Good Ground In Your Shack

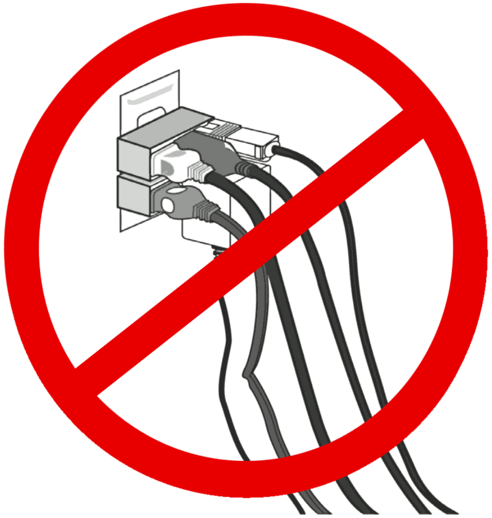
First - Compliance with electrical safety guidelines (electrical grounding system),

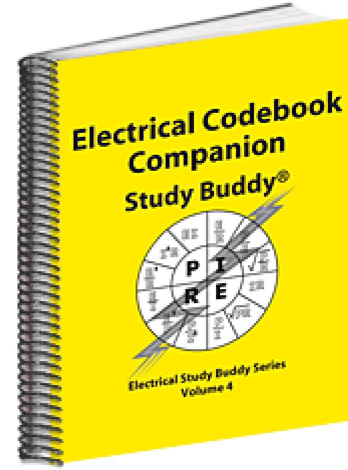
and



Second - Dealing with RFI in the shack (RF grounding system).

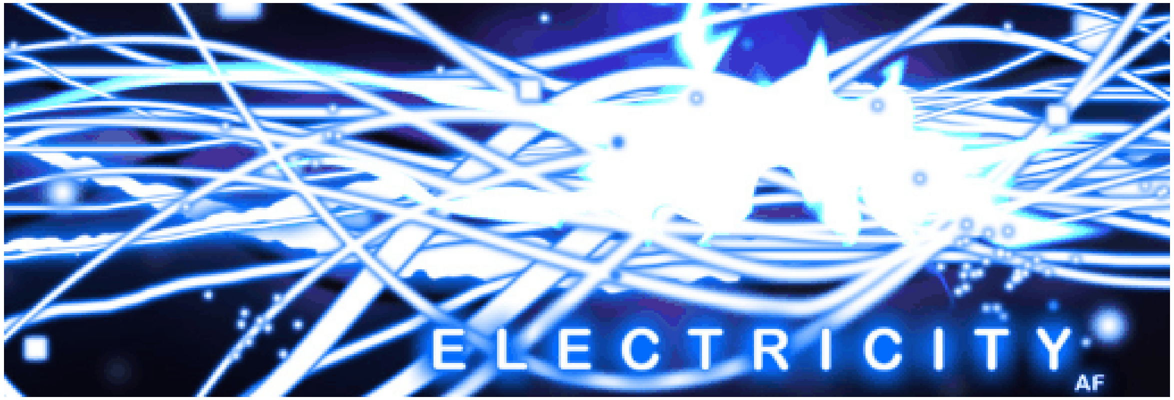
Electrical Safety





Most Hams seem to do pretty well on the electrical side of the shack

Many believe that complying with good electrical safety guidelines is enough to dispel other operating problems. Though seemingly true, this notion is in fact a fallacy.



Signs Things Might Not Be OK

- Microphone bites (nasty RF shock!)
- Gritty and or fuzzy audio modulation (Distortion)
- Malfunction of electronic keyer (sending wrong characters)
- RF shock when touching metallic objects within the shack
- Power supply jitters (the regulated power supply becomes un-regulated!)
- Crazy SWR meter readings
- Desktop computer going crazy
- PC Desktop monitor jitters
- Fluorescent lamp flicker
- Active TTL switch circuit going crazy (Turning ON-OFF-ON by itself)
- Inactive panel meters of separate equipment moving on their own
- When transmitting, a distorted audio is heard over the amplified speaker of the PC desktop.
- Severe Radio Frequency Interference (RFI) to home appliances within the vicinity of the Ham shack

These Are All Attributed to Poor RF Grounding

Scenario 1 (Simple case paradigm)

Radio room on the ground floor of the home QTH.
A good electrical ground system is made by laying out a heavy copper wire about 3 meters long just behind the neatly lined up station equipment. The ground wire runs straight so that each equipment ground lug can accommodate a short flexible grounding wire to reach the ground bus with a very neat connection so that the individual grounding wires did not get meshed up and entangled. The remaining length of the ground bus was led outside to an effectively driven ground rod just outside, near the wall of the radio room.

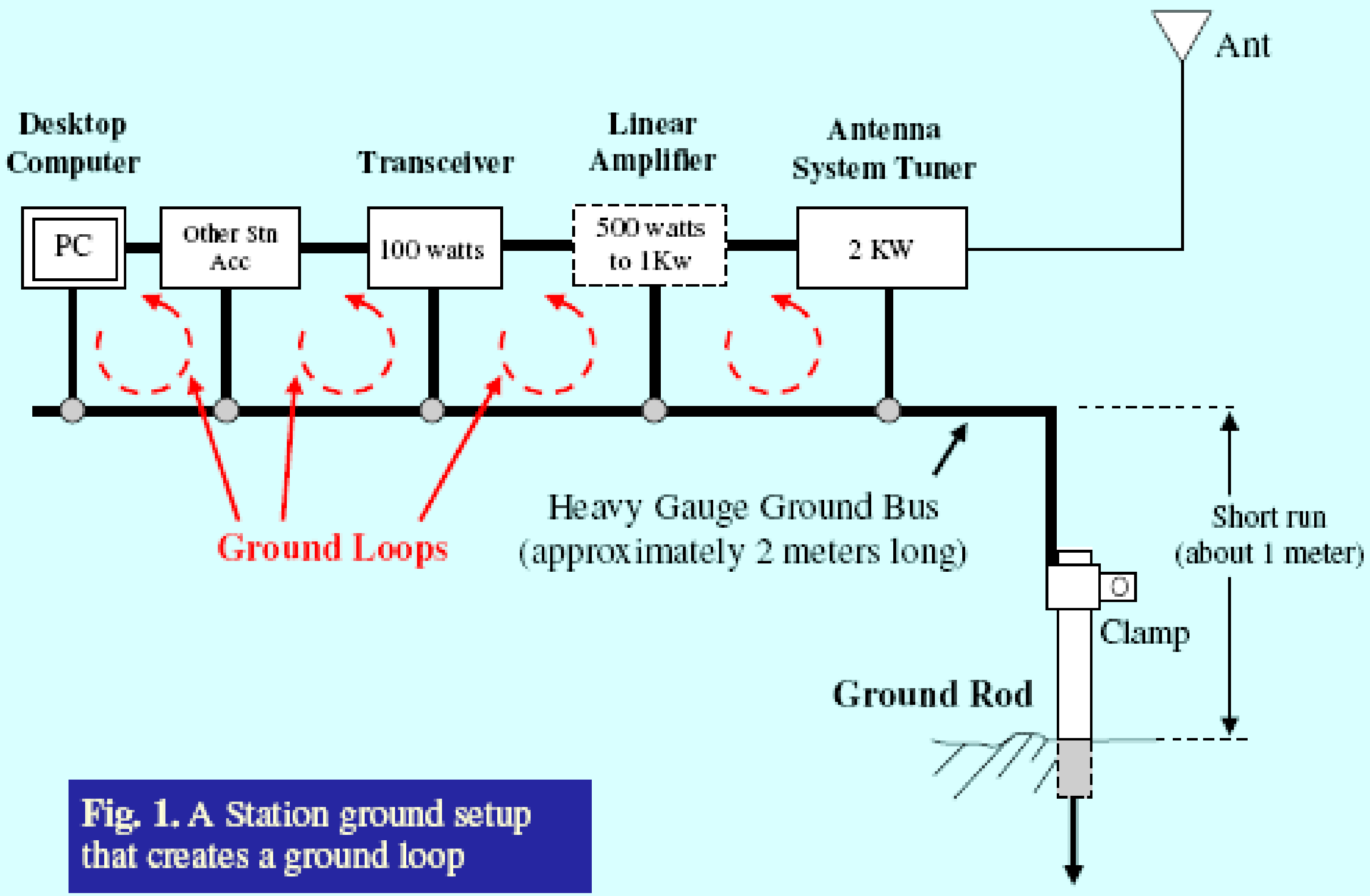


Fig. 1. A Station ground setup that creates a ground loop

Ground loops are formed when the individual ground wires of each equipment are connected to the main ground bus at a point that is distant from each other

The individual station equipments already have their own ground reference but when they are interconnected, grounding each equipment to the main ground bus creates GROUND LOOPS. Each time a ground loop is created, a small inductive coil is formed (the ground wire completes the loop).

When the ground loops are in the near field of RF energy (During transmit mode), these loops will couple to the RF energy (called RF coupling). As the RF energy is coupled to each loop, a fluctuating voltage is induced in unison with the burst of audio modulation of the RF energy. This energy will flow within the system and will seek the least resistance by following the associated circuits and eventually creeping into other internal circuits.

Once the RF is inside these circuits, it will interfere with the normal operating parameters of sensitive circuits thereby creating havoc. RF bleed-over escaping from long interconnecting coaxial cables may also flow within each loop, bathing the whole shack with RF energy.

His new ham shack has an excellent DC electrical ground system but has a VERY POOR RF GROUND SYSTEM

The Solution

Dismantle the present ground wire configuration.
Remove the long ground bus and terminate all ground wires from each equipment into a single point near your ground rod.

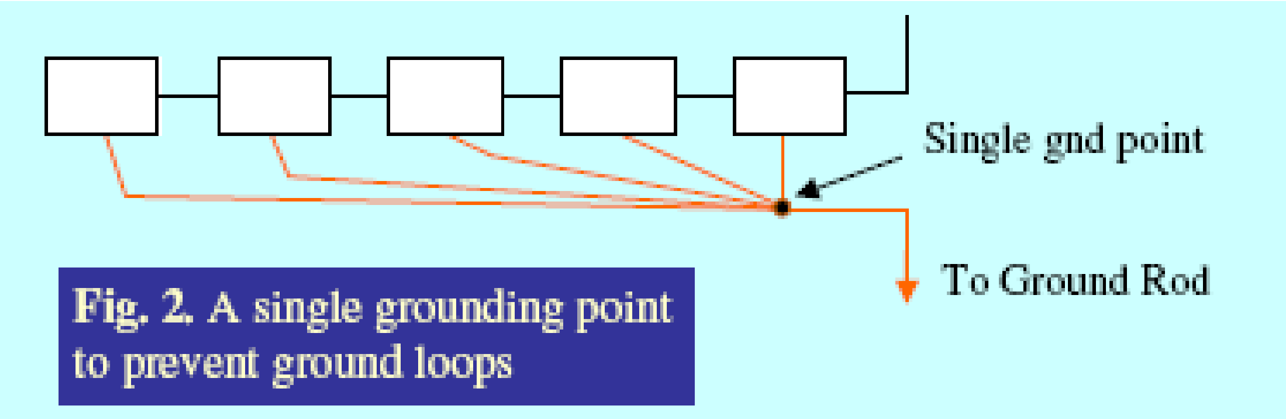


Fig. 2. A single grounding point to prevent ground loops

Scenario 2 (Worst case paradigm) - The Un-grounded Ground

The amateur's signal was strong but the audio was also thin, fuzzy and garbled every time the operator raised his voice over the microphone. RF was all over the ham shack. Every time he spoke over the microphone, the voltmeter of his regulated power supply jumped up and down the scale. The screen of his computer became fuzzy, and his lips were bitten with electrical shock if they touched the metallic case of the microphone. Close neighbours experienced RFI on their TV, stereo and radio sets. Each time he transmitted, his Donald duck's voice was heard over their radio sets

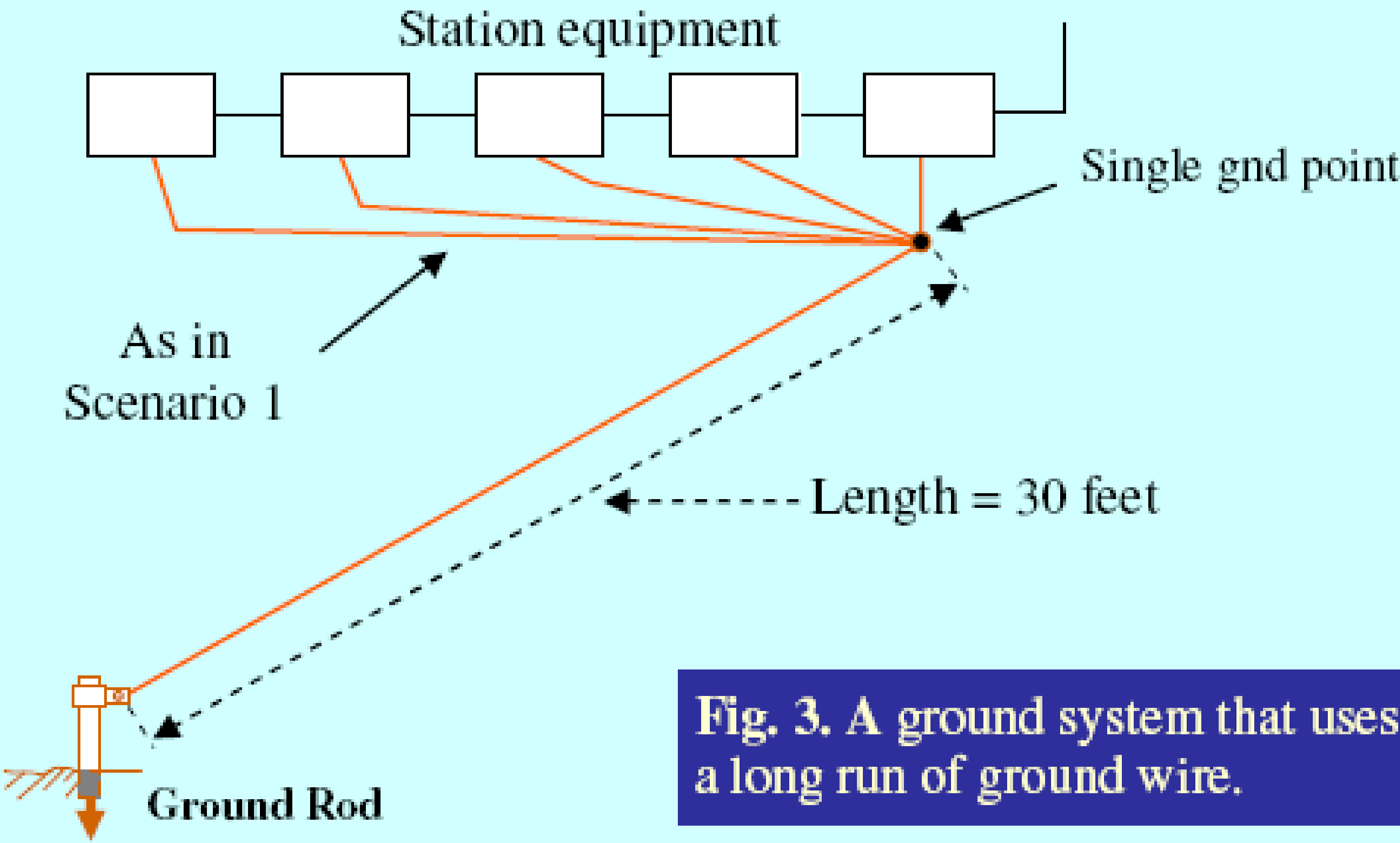


Fig. 3. A ground system that uses a long run of ground wire.

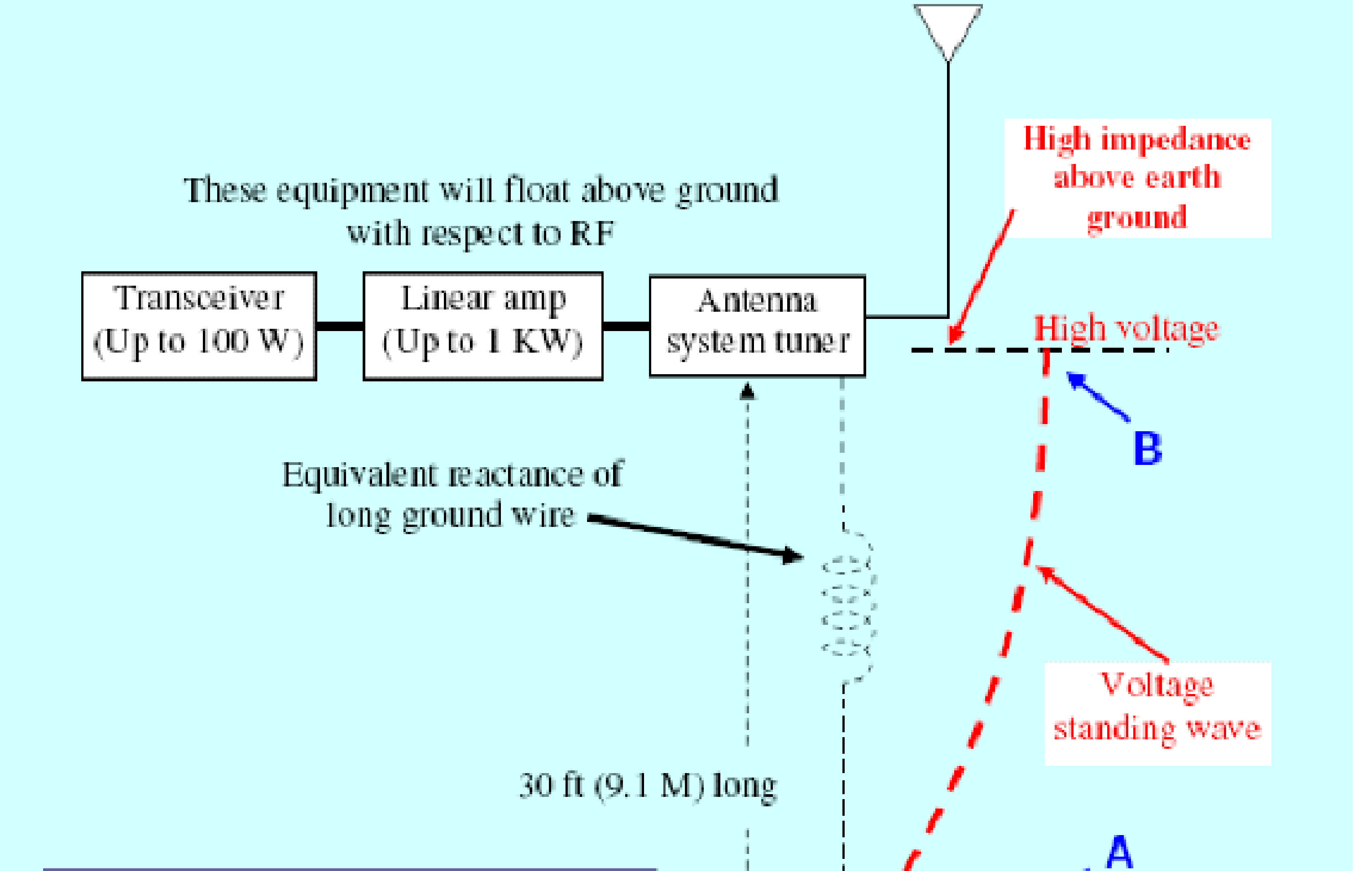


Fig. 4. Equivalent circuit of a ground wire that is ¼ λ of transmit frequency or close to it. Note the induced voltage standing wave.

The ground wire is 30 feet long (9.1 meters); this length is very close to a quarter wavelength at 7 MHz. When you start transmitting at this frequency, your transmitter setup and antenna system will create an image of standing wave throughout the length of this wire. This is by virtue of the RF voltage induced due to resonance. If the long ground wire is ¼ wavelength long at the transmit frequency, this wire will resonate and will act as a radiating element. If the ground wire is less than a quarter wavelength, it will appear as an inductive reactance, the value of which is "Zero" (point "A") at earth ground and "High" at the circuit ground point of the equipment.

If the wire is exactly ¼ wavelength of the transmitting frequency, the ground wire will act like a resonant LC circuit with very high impedance at its top . This reactance will appear like a resistance (called Impedance) to impede the flow of RF current to earth ground, bringing the ground return of all the station equipment to float above the earth ground as if the ground wire is not there (or, as an insulator at RF). Since one end of the wire leads directly to earth ground (Zero Impedance), it follows that the top of this wire (at the circuit ground point of the equipment marked as "B") is the high impedance point (High Z). The voltage standing wave that appears at any point along the length of this wire at the resonant frequency is:

$$E = \sqrt{P \times R} \quad \text{or} \quad E = \sqrt{P \times Z}$$

Where:
E = Voltage P = Power of transmitter Z = Impedance (if AC)
R = Resistance (if DC)

Power Output of Transmitter at the antenna terminal of the system tuner					
100 Watts at 7.035 MHz			500 Watts at 7.035 MHz (Linear amp)		
Length of ground wire	Wavelength (equivalent)	Volts rms at Point "B" (standing wave)	Length of ground wire	Wavelength (equivalent)	Volts rms at Point "B" (standing wave)
10.1 meters	¼ (or 0.25 λ)	351.3	Same	Same	785.6
9.1 meters*	0.225*	316.2*	Same	Same	707.1*
3 meters	0.074	103.9	Same	Same	232.5
1 meter	0.024	33.7	Same	Same	75.4

* Your present grounding setup

RF un-grounded danger zones

Table 1. RF voltage standing waves that are developed at point "B" (See Fig. 4) when lengths of ground wire are equal or less than ¼ λ, at operating frequency.

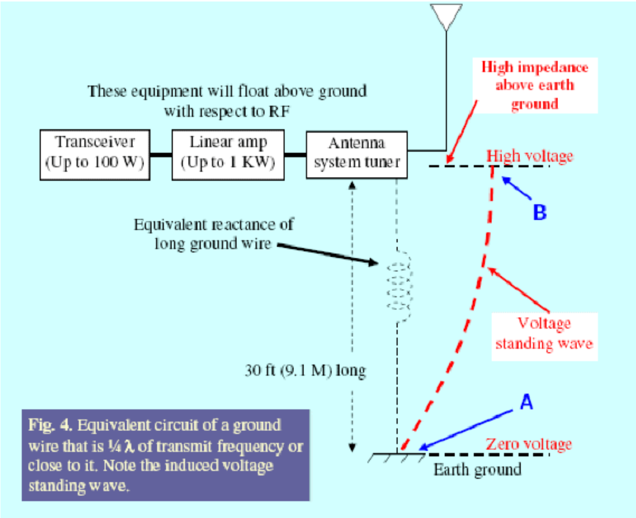
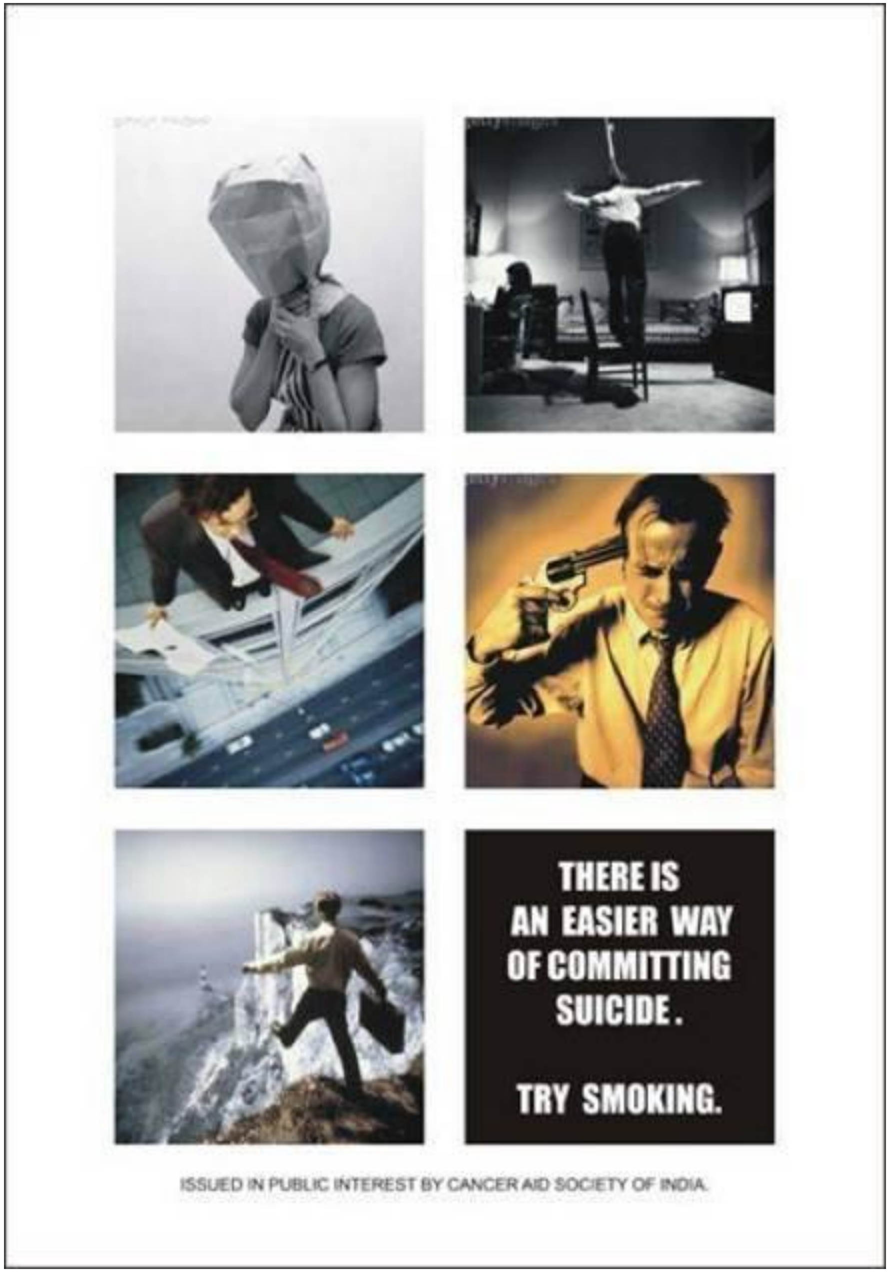


Fig. 4. Equivalent circuit of a ground wire that is ¼ λ of transmit frequency or close to it. Note the induced voltage standing wave.

What To Do

1. Relocate the ground rod to be nearer to the shack so that the ground wire will be as short as possible and will not resonate.
2. Use a short length of ground wire that will not be ¼ wavelength (or its odd multiples), or close to it, of the operating frequency. This is also the reason why your transceiver manual recommends not using this length of ground wire!
3. Install the ground wire so that it will be far from telephone lines and main house wiring to prevent coupling of residual RF energy.
4. Relocate the ground rod and drop the ground wire through another location to be as far as possible from your close neighbour.
5. Match your transmission line impedance equal to the feed point impedance of the antenna or as close as possible to reduce VSWR at the tuner's output terminal

There Has To Be An Easier Way


THERE IS
AN EASIER WAY
OF COMMITTING
SUICIDE.

TRY SMOKING.

ISSUED IN PUBLIC INTEREST BY CANCER AID SOCIETY OF INDIA.

There Is !

Alternative 1 - The Counterpoise

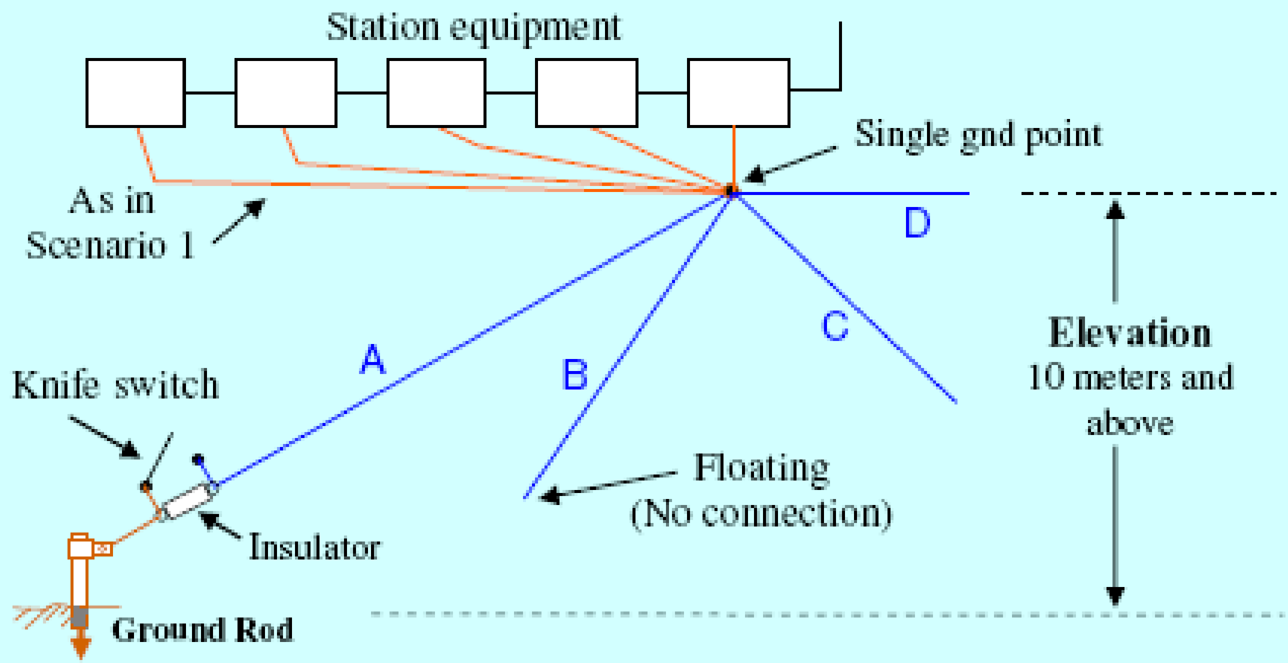


Fig. 5. A counterpoise ground system. Wires A, B, C and D are ¼ λ at each operating band.

1. **Cut each individual counterpoise wire exactly ¼ wavelength of each operating frequency.**

2. **Connect one end of each to the single ground point terminal (see Fig. 5).**

3. **Leave all the opposite ends free and floating (no connection). For better efficiency, stretch and spread each wire in a radial fashion, away from the station equipment as shown in Fig. 5. The position and orientation of the wires is not however critical so that you may want to anchor each at the side wall of the apartment building (of course you have to insulate the ends by using small egg insulators). Another alternate is just to let each wire dangle downwards but still the wires must be spread out. How you will do it will depend on your prolific imagination.**

4. **Now, look for the longest wire (maybe the ¼ l 40 meter band counterpoise) that can reach the ground rod and designate this as your electrical ground. The idea is to use this wire to connect to your ground rod through a knife switch.**

5. **When you are operating the station, the knife switch must be in open position. But when you stop operating and for safety reasons, you must provide an electrical ground. Run downstairs and close the switch. Remember however, to always open this switch whenever you sign ON the station.**

The counterpoise is in effect an artificial ground. One end of the quarter wavelength is connected to the circuit ground of the system (RF generator or transmitter) and the other end is left floating. When the RF generator is active, an image of the signal is developed in this wire and a voltage standing wave is induced. The magnitude of this voltage is similar to a ¼ wavelength antenna at various points along its length. The open end of this wire is high impedance (refer to antenna theory) while the opposite end that is connected to circuit ground of the generator is zero. It follows that the voltage at the generator side is zero (circuit ground) and the open end is high voltage

Notice that the high RF voltage point is now the reverse of the voltage points developed in the case of scenario 2. By taking advantage of this characteristic, the use of the counterpoise will shift the high voltage away from the station equipment. If each operating band has its own separate counterpoise, then each respective counterpoise will function as the operating band is changed, allowing multi-band operation and preventing severe RFI in the shack

CAUTION! ---- The counterpoise wires will radiate RF energy. Make sure that the end of any of the wires will not extend near home appliances within your house and or near your close neighbours.

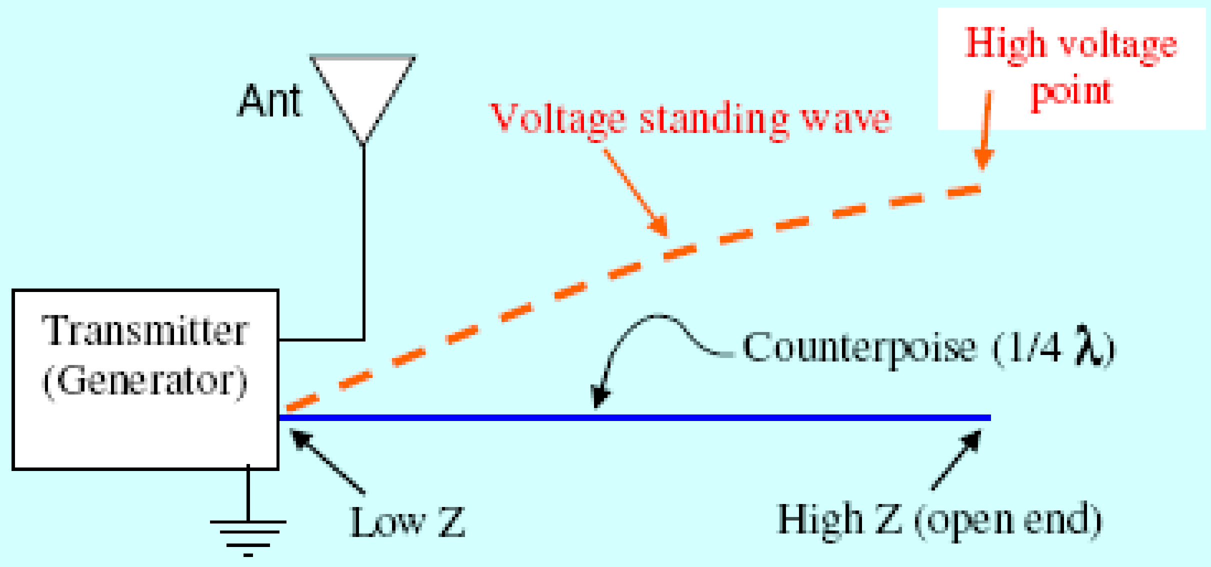


Fig. 6. Voltage standing wave in a quarter wavelength counterpoise

There Is An Easier Way

Alternative 2 -The RF Suppressor Ground System

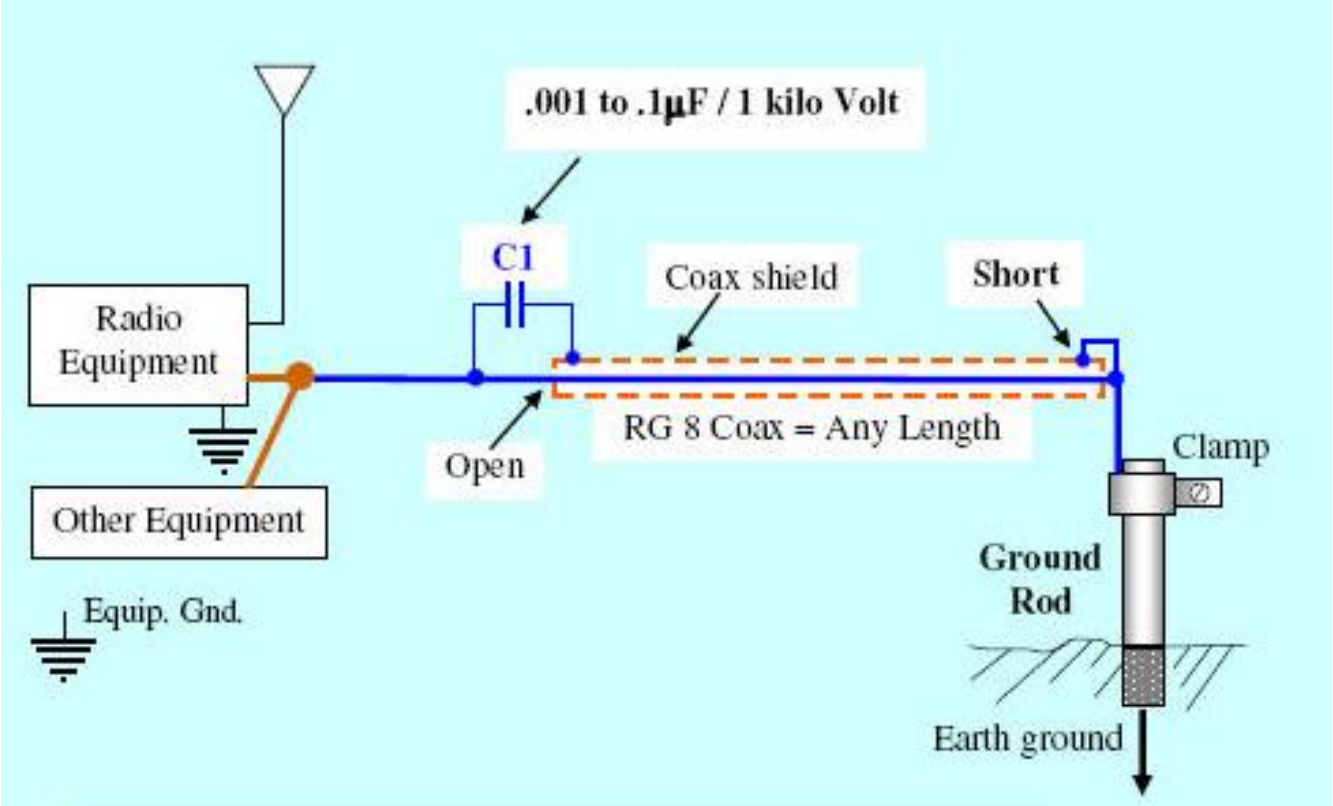


Fig. 7. RF grounding setup with the use of Coax transmission line (RG-8) for the radio equipment that is a long way to the ground rod.

Installation of the RF suppressor – Remove the existing ground wire and replace it with a length of RG-8 coax transmission line, enough to reach the ground rod and into the shack to connect to the ground bus. At one end, short (solder) the coax shield to the center conductor of the RG-8 and the remaining pig tail to be connected (soldered) to a short heavy gauge solid copper wire to reach the ground rod (See Fig. 7). At the other end, strip the coax to reveal the center conductor and remove part of its shield. Connect the center conductor to the circuit ground of the equipment. Leave the coax shield open at this end but connect a ceramic disc capacitor (Marked as C1 = 0.001 to 0.1 µF / I Kilo Volt). One terminal of this capacitor is connected to the coax shield and the other terminal to the center conductor .

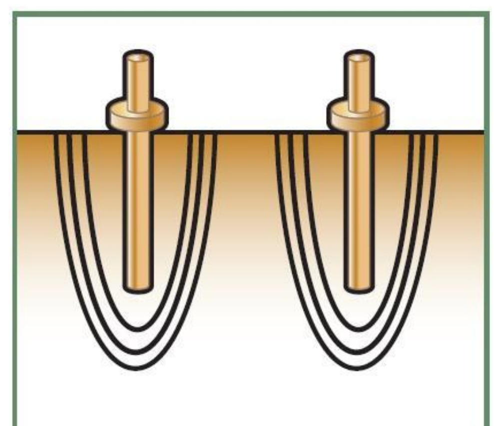
The capacitor value is selectable depending on the lowest operating frequency band and length of Coax. The correct value is selected until RF disappears in the shack (at the lowest band). Or, when your lips doesn’t get to be burned or electrocuted (when touching the metallic mic case) as you speak or transmit. However, YOU MUST USE A HIGH VOLTAGE CAPACITOR RATING, about 1KV minimum, but the higher the better. Otherwise, ZAPPP!!!, this capacitor will explode if a surge of high voltage standing wave will develop instantaneously at or above 500 volts at this terminal

Principle of the RF suppressed grounding system – The ground wire is enclosed effectively by the coax shield so no high voltage standing wave can build up in this wire. However, since the shield is exposed and floating, a high voltage standing wave will appear at the outer surface of the coax shield. This voltage is Zero at the shorted end (ground rod terminal) and high at the open end. When you connect a capacitor between the high voltage end of the coax shield and the center conductor , the impedance of this capacitor is very low at the operating frequency, thus acting as a low impedance load (By virtue of its low reactance = Z, in Ohms) between the shield and center conductor. The RF current will flow easily through this capacitor and is diverted to the center conductor enclosed by the shield and finally to earth ground. The build up of high voltage standing waves between the inside surface of external shield and the center conductor is suppressed because the characteristic impedance of the RG-8 is only 50-52Ω

In order to have an effective propagation for DX work requires a good RF earth ground setup. Merely having improved your equipment ground to earth ground is not a guarantee that you have also an effective RF earth ground…..

Another fact!

See:
http://www.w7aia.org/techinfo_files/docs/RCC_Mar_2007_N7ZXP_Amateur_Radio_Station_Grounding.pdf



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Thanks For Your Attention To The Show